OBSERVATIONS ON THE GREAT LAKES.

REPORTS FROM VESSELS.

The Lake Marine Section of the Forecast Division has received reports for December from the captains of 2 vessels navigating the Great Lakes during the first few days of the month after which they went into winter quarters. Navigation had generally closed by December 15.

REPORTS FROM U. S. LIFE-SAVING STATIONS.

Through the co-operation of the General Superintendent of the Life-Saving Service and the Secretary of the Treasury, the Weather Bureau has received 106 weekly transcripts of journals for the month of December from the keepers of 36 U. S. Life-Saving stations on the Great Lakes. Many of these stations "went out of commission" for the winter during this month. The following special notes by the respective keepers are extracted from these journals:

Middle Island, Lake Huron.—Donald McKenzie, keeper. December 16, the storm-signal displays and telephone service furnished this station by the Weather Bureau have been of great value to shipmasters and owners during the short period elapsed since this most important service has been established; they have been highly appreciated and will be more so hereafter. This station is on the track of all commerce between the lower and upper lakes; the vessels pass close to these islands and attention is given to the signals. The telephone has been useful in the cases of six casualties occurring here, besides giving much information as to weather and telegrams. The number of craft of all kinds passing here from April to December 15 was 21,090 steam and sail vessels, besides many that can not be seen owing to thick weather, making an average daily for eight and one-half months of about 82, not including log rafts. Over 300 craft have been sheltered during storms in this vicinity. The coast above and below these islands is too much exposed for about 100 miles each way to allow of any safe harbors, and the important services rendered here by the Weather Bureau are much sought after and of great importance to sailors.

Sturgeon Point, Lake Huron.—J. E. Henderson, keeper. December 9, more ice in sight than I have seen at this date since 1885.

SURFACE CURRENTS AND FOG ON THE LAKES.

Owing to the close of navigation there have been no special reports of fogs. The general report on the currents has been prepared by the Chief of the Weather Bureau and will soon be published.

NOTES BY THE EDITOR.

THE NORTHERS OF TAMPICO AND VERA CRUZ.

The relation of the hurricanes of the West Indies to the northers of the Mexican coast was partially elucidated by W. C. Redfield in a memoir published in successive numbers of the American Journal of Science for 1844 (second series, Vol. I). Having found that the norther of October 2, 3, and 4, 1837, at Matamoras, was simply the western side of a West Indian hurricane about to recurve in its path, and having found that the paths of other hurricanes were apparently affected by the high barometric pressure on the northwestern side, causing them to move east-northeast rather than northeast or north-northeast, he framed a hypothesis that all Mexican and Texas northers were connected with hurricanes. In his memoir he therefore traces with care the tracks of the centers of revolving storms beginning respectively: 1842, October 2, in the Gulf of Campeche; 1844, October 4, in the Gulf of Honduras; 1837, September 26, on the northern coast of Venezuela. He classes all of these as storms that had moved into the Caribbean Sea and Gulf of Mexico from some distant point, and considers the northers that prevailed in the western portion of the Gulf as due to the western half of these revolving storms. On the other hand, the study of the U. S. Weather Maps showed, even in 1871, that a norther flowing over Texas and the western portion of the Gulf of Mexico was not always preceded by a hurricane to the southward, although it was generally preceded by a barometric depression of several tenths of an inch, and its flow into the Bay of Campeche frequently determined the formation of a whirl that, moving northeastward, might rapidly develop into a hurricane. All the observations given by Redfield in connection with his storms of October 2, 1842, and October 4, 1844, are consistent with their origin in this manner, and the storms of October 1 and October 21, 1893 (see low areas III and XV of that month), apparently belong to that same class. Redfield's hurricane of 1842, August 30 to September 9, pursued a track that kept remarkably close to the parallel of N. 23°, and is believed by him to have passed from the Atlantic to the coast of Durango, Mexico, where the reports from stations show that a violent north wind, followed by a calm and then a furious south wind, advanced westward to about 60 miles from the coast, after which it reached the table-land and was heard from no more. If this storm on the lowlands of Mexico was really the continuation of the hurricane experienced a few days before in the Bahamas, it adds one more to the list of whirlwinds broken up by impinging upon the land, but does not diminish the number of cases in which cool and dry northerly winds blowing from the land upon the warm water of the Gulf of Mexico or the Atlantic ocean have contributed to the formation of a new whirlwind.

A norther prevailed at Vera Cruz from September 29 to October 2, 1842; its maximum force was at midnight September 30. Redfield states that the hurricane of which he considers this to have been the western quadrant must therefore have been moving very slowly at that time; that this protracted duration is not unfrequent, but rather common in the northers at Vera Cruz; that this may be ascribed with probability to the cessation of the westerly progression of the storm and the gradual commencement of an easterly course. This explanation by Redfield implies that a hurricane had moved west or west-northwest through Honduras, Yucatan, and Mexico and turned to a northeastward course about October 2 in the Bay of Campeche. A transference of a revolving system of hurricane winds across or over the mountains of Central America is, however, difficult to believe until conclusive proof is offered, and especially in view of the fact that while this is supposed to be going on the volcanic smoke and the upper clouds of these regions continue to flow from west-southwest undisturbed.

The maps of International Simultaneous Observations indicate quite clearly that when a norther prevails in the Gulf of Mexico or the Caribbean Sea there exists a wide-spread barometric depression on the Pacific coast of Mexico or in the northern portion of South America, respectively, but not necessarily any hurricane, properly so-called. The flow of cold air determines the formation of a hurricane center somewhere within this general depression if all conditions are favorable. In a similar way, a general depression in the Indian Ocean is followed by an inflow of cooler or drier air and the formation of a typhoon center somewhere within the general depression. So, also, the typhoons of the China Sea are sometimes determined by the flow southward of air from the interior of Asia.

The norther that began September 29, 1842, at Vera Cruz and was at its maximum by midnight had moderated materially by October 3, but the wind continued northwest until October 4. On the 29th the Mexican brig "Secunda Fama" sailed from Vera Cruz and on October 2 was inside of the bar at Tampico; during the whole of this interval she seems to have had no experience of the norther, but on the latter date was suddenly attacked by it and driven on the reef of Lobos Island, about 45 miles south of Tampico. The schooner Caroline when about 100 miles east of Matamoras on October 1 ran into the gale which was blowing from the northeast then and there, but as she sailed eastward through it the wind became northerly in the central portions and northwest as she passed eastward from the center, so that she was driven near to the Campeche bank.

These and other reports gathered by Redfield are consistent with a rather different explanation of the nature of this and other northers on the Gulf, and one that I have often advocated. We have here a mass of cool, dry air flowing from Texas nearly due south or south-southeast and steadily reinforced by fresh supplies from the northward. In the central axis of this stream the current preserves a nearly uniform movement forward, but both in front and on either side the air has to push opposing air away, and there is, therefore, a steady outflow so that on the easterly side of the axis northwesterly winds are found, while on the western side northeasterly occur, and these may curve around even to westerly and easterly, respectively. The winds on the western side of the axis are moving in the wrong direction to form a permanent cyclonic whirl, they are pushing toward the Mexican coast and piling up clouds and possibly forming local small whirls before they reach the table-lands, so that an observer on the table-lands, looking northeastward, sees the ocean of clouds below him long before he feels the northeasterly wind, even if it comes at all: it thus happens that Tampico and Matamoras experience these winds several days later than Vera Cruz. On the eastern side of the axis the deflection of the wind conspires with the rotation of the earth to the formation of hurricanes, which subsequently move northeastward over the Gulf of Mexico with rapidly increasing velocity.

Vessels that keep near the Mexican coast avoid the severity of the gale that prevails 50 miles away to the eastward, but they experience short-lived whirls and squalls; for instance, Redfield quotes from the record of H. M. S. "Thunderer," in December, 1840, at Vera Cruz; just before the norther commences the scud can be seen overhead progressing rapidly from southeast to northwest, which shows that the northerly wind is rising and flowing back on itself toward the northwest. The most certain forerunner of the norther was, in those days, well known to be a barometric fall of from 0.2 to 0.4, which is followed in a short time by northerly winds at Vera Cruz. The northers of the month of May to August in Mexico are a different type of storm; they are known as the "northers of Muerto Colorado," and begin at northeast and settle at north-northwest. During these months the southwest hurricanes blow on the Pacific coast of Mexico, and, like the "Muertos," are due to the area of low pressure that then prevails from Arizona southward and southwestward. When this area of low pressure disappears in the winter months, the west coast of Mexico experiences the violent local storms known as "Papagello," "Tapayaguas," or "Tehuantepec," which are violent from the northeast and north-northeast, and represent the flow of dry, cold air from the Mexican plateaus down to the Pacific. These various styles of northerly winds are, of course, to be distinguished from the northerly gales that descend from Texas, and are known as the "northers of Texas and Vera Cruz," and which also extend to Yucatan, Honduras, and occasionally to Panama; but when they extend so far southward as this they imply the presence of a severe hurricane passing from the West Indies northward into the United States.

On the norther of December 1, 1893, Prof. G. Batturoni, of the Meteorological Observatory of the Literary and Mercantile Institute at Vera Cruz, reports to the effect that it blew with extraordinary violence, causing serious damage and some loss of life. "My observatory had forewarned the port of Vera Cruz that a strong norther might be expected between November 29 and December 1, and it actually began with a feeble north wind on the 30th, which continued throughout the day until it backed in the evening to west-southwest. During December 1, the wind was from east-southeast and southeast rather stronger than ordinarily, but not exceeding 6 miles per hour and backing to the south during the night and finally returning on the 2d to east-southeast. On the 2d the wind again backs from east-southeast to west, and then south returning to east-southeast, and, finally, by 1 a. m. of the 3d, to west. On the 2d my observatory hoisted the signal: 'the norther is at hand.' During the nights of these days lightning without thunder continued uninterruptedly. During the daytime the peaks of Orizaba, the 'cofre' of Perote, and all the peaks of the Cordilleras showed all the symptoms that are invariably preliminary to a norther, the volcano of San Andres and the Sierra of San Martin were clearly visible after the 1st, the typical cloud of which I have previously spoken was imperfectly formed on the 1st, but perfectly definite at 4 p. m. of the 2d, but its position on this occasion was to the west-southwest instead, as ordinarily, to the west-northwest.

"During the nights from the 29th to the 2d the sea roared more than it usually does; the noise increased on the 1st and the 2d to a remarkable degree; the sea continued very high, and the sunset of the 2d showed persistent reddish tints of a very pronounced copper-red over the whole horizon, except from the south to the east-southeast.

"On the 3d day broke with the wind from the west, at 8 a. m. it was from the northwest, very feeble, and at 9.33 nearly north, but continued weak. A thick, black cloud, resting on a thick layer, rolled along from the north-northeast rapidly to the west, and an hour later the cloud suddenly spread and the first gust, with a velocity of 10 miles per hour, was felt at the observatory. At midday the velocity had doubled; at 1.30, quadrupled; and afterwards it increased until it reached a velocity of 60 miles; it continued, with a mean velocity of 55 miles, for more than seven hours; the whirling gusts were so violent that they demolished the walls of the houses most exposed to them.

"The wind continued, with terrible gusts, until 10 p. m.; at 11.30 p. m. its force seemed to diminish, but from midnight until 3 a. m., December 4, it returned to its former violence; at 4 a. m. it had a velocity of 40 miles; at 6 a. m., only 30; at 10.24 a. m., and, finally, at 3 p. m., only 15 miles per hour. The schooner 'Jamapa' was dashed on the coast, as well as several other vessels of less importance. Three houses in the suburbs fell to the ground, killing a poor woman and wounding 2 other persons; the works of the port suffered also; in the city the roofs of several houses were blown off; at La Piedra, nearly 10 leagues from here, the same thing occurred; iron plates were carried 30 meters; at Soledad also, 10 leagues distant, the wind tore up trees and marked its passage with disaster everywhere, particularly to the working class. This norther was also felt at Tampico."

If now we turn to the United States Weather Maps we find that an area of cold northerly winds was advancing rapidly southward on the 2d and 3d from the Dakotas, Colorado, and New Mexico to the Texas coast. The front line of this cold wave is the region where comparatively warm southerly winds are suddenly displaced by the under-running current of cold northerly winds. This is the front of the norther, and its progress may be distinctly traced by the shifting of the winds at the Weather Bureau stations. I have drawn lines showing the progress of this advancing norther during the 2d and 3d, which are introduced on map No. I, and show that although its progress was quite uniform over the land area at a rate of about 40 miles per hour in a southeasterly direction from the 2d, 8 a. m., until the 3d, 2 a. m., and even after that, as it passed over the Atlantic States and the mainland of Mexico; yet the moment this air reached the Gulf coast between Galveston and Corpus Christi it doubled its rate of advance toward the south and reached Vera Cruz at 10.30 a. m. of the 3d, or eight hours after leaving Galveston and Corpus Christi, being at the rate of about 80 miles per hour. It probably reached Frontera, Mexico, and Campeche and the west coast of Yucatan within an hour after touching Vera Cruz. Through the central portion of the region of flow the winds must have been north-northeast and north-northwest, as shown by the northerly arrows; to the east of this region the winds would incline to northwest, while to the west of this center they would incline to northeast, as, in fact, is also observed to be the case with the winds at stations on land. The north and northeast winds between Vera Cruz and Tampico produce the temporary whirls and gusty weather experienced along that coast. The north and northwest winds experienced from Campeche to Florida on the 3d and 4th must have conspired with the rotation of the earth to increase the circulation around a storm-center that was apparently east of Florida and north of Cuba on the 4th, 8 p. m., and that subsequently developed into low area No. IV of the United States series. Thus, the norther on the coast of Mexico is an incident in the flow of cold air, as it followed behind low area No. I and moved onward to meet low area No. IV. But, in accordance with what little we know of the mechanics of the atmosphere, it does not seem proper to consider either of these low areas as the cause of the inflow of this northerly wind, or of the high barometer and low temperature that attended it; on the contrary, it is more rational to keep in mind the great areas of moderately low pressure and to say that the descent of air into these from the areas of high pressure usually initiates the whirls and special lows that we call storm-centers.

TEMPERATURE OBSERVATIONS AT THOMPSON, WINDHAM CO., CONN.

Miss Ellen D. Larned communicates the following summary of her observations at Thompson, Conn., N. 41° 55′, W. 71° 50′. She states that her record began January 1, 1852, and has been continued uninterruptedly, except during the years 1884–'85: "I have taken great pains with the observations and summaries and think that they are mainly accurate. I was absent in June, 1853, but the maximum temperature for that month was recorded by my parents. My thermometer hangs in the same shelter as at first, but the trees have heavier foliage so that for a number of years the mercury has not risen so high as formerly, and since June 24, 1884, it has not risen above 90°, but it is perfectly open on all sides and the position is a good one. The exact location is on a hill in the town of Thompson." Miss Larned is well known as the author of the "History of Windham County," one of the most important county histories that has been published. This county has been settled since 1680, and it would be very interesting if some one as familiar with the subject as Miss Larned could gather together the scattered items that may be on record, and which would present a nearly complete history of the climate and meteorological phenomena during the past 200 years. A list of "coldest days" at Thompson will be found in the MONTHLY WEATHER REVIEW for May, 1888.

Summary of temperature observations, 1852 *to* 1894 (*omitting* 1884 *and* 1885), *at Thompson, Windham Co., Conn., by Miss Ellen D. Larned.*

Month.	Mean temperature.	Extremes of monthly means.				Extreme observed temperatures.					
		Maxima.		Minima.		Maxima.			Minima.		
		Year.	Mean.	Year.	Mean.	Year.	Day.	Temp.	Year.	Day.	Temp.
January	22.46	1880	33.22	1857	10.80	1876	1	68	1857	23	−22
February	26.01	1857	33.50	1875	19.20	1857	25	64	1861	8	−20
March	31.05	1871	39.88	1872	24.35	1861	30	73	1863 1872	13 5	− 6
April	44.30	1878	49.76	1874	36.68	1861 1872	23 26	84	1874	5	11
May	56.00	1880	62.33	1882	49.27	1880	26	91	1882	3	27
June	65.16	1865	69.46	1881	59.77	1863	.....	95	1859	11	39
July	69.89	1887	74.54	1859	64.89	1866	16 17	95	1859	5	44
August	67.36	1870	71.77	1859	61.49	1864	1	93	1855 1856	31 26 27	43
September	60.60	1881	66.20	1860	56.12	1881	7	91	1888	30	30
October	49.40	1879	54.63	1868	42.82	1884	4	78	1879 1886	26 17	20
November	38.58	1870	43.12	1873	30.15	1860	1	73	1875	30	− 1
December	27.95	1091	36.80	1872	10.64	1889	25	62	1883	23	−14

Annual mean temperature at Thompson, Windham Co., Conn., so far as reports are at hand in the archives of the Weather Bureau.

Year.	Mean.	Year.	Mean.	Year.	Mean.	Year.	Mean.	Year.	Mean.
	°		°		°		°		°
1852	46.8	1861	44.5	1869	46.9	1877	49.0	1885	......
1853	......	1862	46.7	1870	49.6	1878	49.0	1886	46.6
1854	47.4	1863	......	1871	......	1879	47.4	1887	......
1855	48.5	1864	47.4	1872	46.2	1880	49.1	1888	44.4
1856	45.2	1865	48.7	1873	45.7	1881	47.0	1889	47.8
1857	45.6	1866	47.2	1874	46.5	1882	46.2	1890	46.4
1858	45.1	1867	......	1875	......	1883	......	1891	47.6
1859	45.0	1868	44.9	1876	47.4	1884	......	1892	46.2
1860	46.4								
Average	......	......	......	......	......	......	......	......	46.8

THE OBSERVATION OF THE HIGHEST CLOUDS.

An observer at Potosi, Mo., reports that, at 5.30 a. m., December 16, there appeared in the sky nearly overhead a bright redness of a tint like that of the rising sun; it lasted for about fifty seconds; it covered an area whose outline was that of the figure known in geometry as a "lune," whose southern vertex was southeast of the zenith, at a point corresponding to the position of the sun at 11 a. m., and whose northern vertex was about the same distance northeast of the zenith, so that its axis lay almost directly north and south. This reddish light was not caused by a comet or meteor, as many supposed, nor was it an auroral light, but was evidently the illumination by the sun's rays of a high, delicate cirrus cloud. On that morning a region of clear, cold air was moving eastward over Missouri and all the clouds above Potosi (N. 38°, W. 90) must have been composed of snow or ice spiculæ whose reflections are more perfect than those from globules of water that form ordinary cumulus clouds. The region to the east of Potosi for several hundred miles had experienced rain or snow and was covered with moist and cloudy air; the sun's rays, as seen through such an atmosphere in the early morning are generally of a cherry red color, due to the absorption of the more refrangible green and blue rays by the moist atmosphere. At 5.30 a. m., December 15, at Potosi, it is about 1 hour and 40 minutes before sunrise, and allowing for the refraction by the air we find that if the cherry-tinted rays of the sun were at that time to illuminate a cloud in the position seen by the observer at Potosi the cloud must have had an altitude of at least 10 miles. In the course of a few minutes after sunrise we ordinarily observe the cherry tint of the sun's disc to become yellow and finally white, owing to the fact that its rays no longer pass through such a long stretch of the dense lower atmosphere. In the same way at Potosi the reddish-tinted cloud, in the course of a minute, begins to be illuminated by the rays of the purer sunlight and appears pale white instead of red, and becomes indistinguishable from the general whitish haze of the sky. This accounts for the fact that the observer saw the haze last for only about fifty seconds. At this time the sun was about 18° below the horizon.

In order to determine the heights of the highest cirrus clouds only two methods have as yet been successfully attempted, namely, the measurement of altitude and azimuth by two or more observers some distance apart, or otherwise the determination of the exact time at which clouds are first seen illuminated by the morning sun, or last seen by the setting sun, coupled with which should be an approximate determination of the altitude and azimuth of the cloud. In the clear sky of the early morning, and especially in the dry weather of summer, observers will be surprised to find how very early in the morning these delicate clouds may be observed, whence it follows that they must be correspondingly high, in fact at latitude 52° and on the 20th and 22d of June they are reported to have been seen at midnight when the sun is only 15° below the northern horizon.

THERMAL BELTS, FROSTLESS BELTS, OR VERDANT ZONES.

These are local names given to certain regions on mountain sides within which nocturnal frost rarely or never occurs in the spring time, although freezing temperatures occur in the winter time, consequently tender vegetation flourishes with remarkable vigor in these regions. The following are the only references to thermal belts in the United States at present known to the editor, but as such regions are especially important to the horticulturist and agriculturist it is hoped that the correspondents of the Weather Bureau will bring these thermal belts to notice wherever they occur in order that their meteorological peculiarities may be better understood.

In the Agricultural Report of the Patent Office for 1861, Mr. Silas McDowell, of Franklin, Macon Co., N. C., describes the verdant zone in that county in the valley of the Little Tennessee River; it occupies the region between 300 and 700 feet above the valley of the river, which latter is about 2,000 feet above sea level; on tracing this zone up among the smaller tributaries of the Tennessee River, he found that in the higher valleys, where the bottom land is about 3,900 feet above sea level, the verdant zone lies between 4,000 and 4,100. Within this zone frost never injures the vegetation and the most tender grapes never fail to produce abundant crops.

Prof. J. W. Chickering, Jr., in the bulletin of the Philosophical Society of Washington, March, 1883, and in the American Meteorological Journal, Vol. I, describes the following thermal belts:

In Polk County, N. C., along the eastern slope of the Tryon Mountain range, in latitude N. 35°, the thermal belt begins at the base of the mountain, at an elevation of 1,200 feet above the sea, and extends up 2,200 feet, being most perfect at about 1,500. It is about 8 miles long, and distinguished by magnificent flora such as would be characteristic of a point 3° south of the actual latitude.

Prof. John Leconte, of Berkley, Cal., in Science, Vol. I, p. 278, states that at Flat Rock, near Hendersonville, Henderson Co., N. C., on the flank of the mountain spur adjacent to the valleys of the Blue Ridge, he has also observed a frostless zone; the valley is about 2,200 feet above sea level, and the thermal belt is 200 or 300 feet above the valley.

Mr. J. W. Pike, of Vineland, N. J., states that among the mountains of California he has observed that during the night the cold is much greater in the valleys than on the terraces several hundred feet above, due to the settling of the cold air, so that a thermal belt is formed at that height separating the frosty valleys from the colder highlands.

In the Tennessee Journal of Meteorology for January, 1894, published by that State Weather Service, the author describes a thermal belt between Los Angeles and the Pacific Ocean; it traverses the foot hills of the Cahuenga range and has an elevation of between 200 and 400 feet, and a breadth of about 3 miles; it occupies the midway region of the range.

In the American Meteorological Journal, Vol. I, Mr. S. Alexander describes a thermal belt, in which the peach tree flourishes, in the southeastern portion of Michigan: he shows that the cold island discovered by Winchell in that region is really the bottom of a topographical depression into which the cold air settles; it is a long valley surrounded by a belt of elevated country from 50 to 600 feet above lakes Michigan and Huron. The valley and the isotherms trend northeast and southwest from Huron County through Sanilac, Lapeer, Oakland, Livingston, and Washtenaw to Hillsdale counties. The highlands of this region are all much freer from frost than the lowlands, and all much more favorable to early vegetation. He does not state that any point is high enough to be above the thermal belt, but that, in general, two equal parallel thermal belts inclose the cold island between them.

It is generally conceded that these thermal belts depend both upon the drainage of cold air downward into the lower valleys and the freedom of radiation from the surface of the ground to the clear sky overhead. During a still night when frosts occur the surface of the hillside cools by radiation and hence cools the air in contact with it; the latter flows downward as long as its cooling by radiation and conduction exceeds its dynamic warming by compression. Inasmuch as its cooling depends on contact with a still colder soil or plant it soon accumulates in the lowlands as a layer of cold air, which grows thicker during the night by the steady addition of the thin layer of descending air in contact with the ground on the hillsides. The warmer air, that has not yet had an opportunity to cool by contact with the ground, floats on top of the cold mass; it spreads out toward the hills, and is continuously furnishing its heat to the adjacent hillsides as fast as it comes in contact with them before it also cools and descends. The formation of the thermal belt seems to depend largely upon this gentle circulation during the night time. The lower limit of the belt is defined by the depth of the accumulation of cold air in the confined valley and rises higher in proportion as the night is clearer and longer, and also in proportion as the valley is more or less perfectly inclosed; the upper limit of the the thermal belt may depend upon the strength of the wind and the general temperature of the air, but if there be no wind then it depends equally on the freedom of radiation to the clear sky and on the above-described circulation of air.

A COMPARISON OF PREVAILING AND RESULTANT WINDS.

Owing to the labor involved in computing the resultant wind for each month, it has been the custom to select the wind that occurs most frequently and speak of that as the prominent feature in the wind movement at each station; such so-called prevailing winds have been published on Chart No. II of the MONTHLY WEATHER REVIEW during the preceding years, in connection with the isobars and isotherms for each month. It is, however, evident that if the isobars and winds that prevail at any moment are to be compared with each other then equally must the mean isobar and the mean wind of the month or year be compared. If there were but slight changes in barometric pressure and wind direction at any station during the month, the inclination of the mean wind to the mean isobar would be a simple linear function of the inclinations shown on the individual simultaneous maps, but as pressure, and especially wind direction, go through a wide range of diurnal, annual, and non-periodic changes, it is not necessary that any simple relation should hold good between the monthly means and the individual values, except in seasons of steady winds. By the mean direction of the wind must be understood a resultant based upon all individual observations and already, many years ago, meteorologists had discussed the question as to how this resultant could best be computed.

Prof. J. H. Coffin, in his "Winds of the Northern Hemisphere," Washington, 1853, showed by an extensive computation that no great error would be produced in the climatological results that he published if Lambert's formula, or some equivalent analysis of the winds, be applied on the assumption that the wind blows with equal force or velocity from each of the recorded directions. In order to establish this generalization it was necessary for him to calculate the resultants, both for the actual observed wind force and direction, and again for the assumed uniform velocities; this calculation he carried out for observations during 397 months at 103 different places. In 1857 he executed a more extensive discussion of the subject, based on an aggregate of 8,589 months at 418 places on the American continent, the observations having usually been made three times a day; the result of this great work is given in Coffin's "Winds of the Globe," Washington, 1875, pp. 638–656, where the discussion is also extended to include the movements of the clouds. By charting his results he was able to show that both the magnitude and the direction of the "resultant wind movement," computed by taking strict account of the velocity of the wind, differed systematically from the magnitude and direction of the "resultant wind direction," computed by assuming all winds to have an equal velocity. These differences may be considered small and negligible in a general survey of the climatology of the globe, but become important when we study the laws of the mechanics of the atmosphere.

The establishment of "double registers" and "triple registers," giving continuous records of the direction and movement of the wind at 67 stations of the Weather Bureau (the other stations have registers of movement only), furnishes material for a more thorough investigation of this subject within the United States than was practicable to Prof. Coffin, who relied mostly upon observations taken three times a day in all parts of the world. It is now proposed to analyze the wind records and deduce the resultants for these 67 stations of continuous registration, and to publish the results monthly in this REVIEW during 1894. The first point I shall consider is how nearly the resultant movement, calculated by giving a proper weight to each velocity, will agree with the resultant direction, calculated by assuming a uniform velocity. As nothing definite can be at present stated in respect to this question, more than what has been given by Coffin in 1875, and by Supan in 1881 in his "Statistics of the Lower Atmospheric Circulation," and as it seems on the other hand necessary to print in connection with the monthly isobars something more appropriate than the "prevailing wind" deduced from observations at 8 a. m. and 8 p. m., it is proposed to publish monthly during 1894 on Chart No. II the "resultant wind directions" deduced from the 8 a. m. and 8 p. m. observations, and to substitute, at some future time, such further improvements as may be shown to be necessary after a study of the "resultant wind movements" deduced from self-registers.

The resultant movements for the 67 stations of self-registration based upon the hourly readings of the anemographs, or on about 720 observed hourly movements in a month of 30 days, will be given in tabular form about as in the present article; the resultants for the remaining regular Weather Bureau stations must necessarily be based upon the observations made at 8 a. m. and 8 p. m., 75th meridian time (or the hours for which the weather maps are compiled daily), and they will therefore need a correction to make them comparable with the results of self-registration and with the monthly mean isobars; this correction must be determined empirically when sufficient data have accumulated.

The following table (A) contains the necessary data from each self-register for the month of December, 1893; the contents of the columns are as follows: Columns 2 and 3—the prevailing wind, viz., that most frequently observed, its direction, and duration in hours. Columns 4 and 5—the total movement in all directions for 744 hours and the average hourly movement found by dividing by 744. Column 6—the "resultant direction," assuming the wind to have always a uniform velocity; this is equivalent to giving each hour of wind and calm alike the same weight, and as the few blanks that occur in the registers have been approximately interpolated, or uniformly distributed, this resultant may be assumed to be based on the complete month. Column 7—the duration in hours of this resultant, considered as a wind that has blown with the average velocity that was implied in the above assumption of a uniform velocity. Column 8—the approximate average velocity in this resultant direction, found by dividing the resultant movement, expressed in miles in column 10, by the resultant duration, expressed in hours in column 7. Column 9—the direction of the "resultant movement," computed by using the miles actually traveled each hour, as read from the registers. Column 10—the resultant movement itself in miles. Column 11—the azimuth of the resultant movement will differ from the azimuth of the resultant direction in proportion as the wind velocities are unequally distributed among the points of the compass; the difference of these two azimuths is given in column 11; azimuths are counted around the circle from zero at the south through 90° at the west, and if the azimuth of the resultant movement is greater than that of the resultant direction the difference in column 11 is called positive; the azimuth of the movement is equal to that of the direction plus the positive, or minus the negative, differences given in column 11; these differences are usually quite small, but the extreme range is from plus 39° to minus 47° and, on being charted, they are seen to be grouped together in such a way as to indicate that the stronger winds in one portion of the country are more northerly, southerly, easterly, or westerly than is consistent with the assumption of a uniform wind; thus it happens that the resultant movement differs systematically from the resultant direction for at least two reasons, *i. e.*, (1) very local peculiarities of instrumental exposure and topographic contour, (2) very general peculiarities of the atmospheric circulation and the paths of high

TABLE A.—*Prevailing and resultant winds from self-registers for December*, 1893.

Station.	Prevailing wind.		Total movement.		Resultant direction.			Resultant movement.		Azimuth of movement minus direction.	Ratio of resultant movement to total movement.
	Direction from.	Duration.	Monthly.	Hourly average.	Direction from.	Duration.	Average hourly velocity.	Direction from.	Movement.		
(1)	(2)	(3) Hours.	(4) Miles.	(5) Miles.	(6)	(7) Hours.	(8) Miles.	(9)	(10) Miles.	(11) °	(12)
Abilene, Tex	s.	179	9,619	12.9	s. 42 w.	215	17.0	s. 36 w.	3,675	− 6	0.382
Albany, N. Y	nw. s.	213 212	6,259	8.4	n. 84 w.	165	9.5	s. 85 w.	1,560	−11	0.249
Alpena, Mich	sw. nw.	174 174	8,100	10.9	s. 81 w.	270	9.2	s. 78 w.	2,560	− 3	0.316
Atlanta, Ga	nw.	197	7,901	10.6	s. 77 w.	151	14.5	n. 87 w.	2,190	+16	0.277
Augusta, Ga	nw.	135	4,442	6.0	n. 45 w.	135	10.0	n. 58 w.	1,350	−13	0.304
Baltimore, Md	sw.	176	5,798	7.8	s. 89 w.	211	14.0	n. 82 w.	2,712	+ 8	0.473
Bismarck, N. Dak	nw.	251	7,134	9.6	n. 13 w.	127	18.4	n. 22 w.	2,332	− 9	0.327
Boston, Mass	w.	245	8,760	11.8	n. 84 w.	455	10.1	n. 79 w.	4,602	+ 5	0.525
Buffalo, N. Y	w.	172	11,535	15.5	n. 85 w.	303	23.6	s. 88 w.	7,142	− 7	0.619
Chicago, Ill	sw.	254	16,387	22.0	s. 69 w.	415	23.6	s. 61 w.	9,780	− 8	0.597
Cincinnati, Ohio	nw.	186	7,009	9.4	s. 45 w.	258	12.3	s. 66 w.	3,175	+21	0.453
Cleveland, Ohio	se.	199	12,675	17.0	s. 15 w.	322	17.8	s. 19 w.	5,723	+ 4	0.452
Columbus, Ohio	sw.	207	9,314	12.5	s. 58 w.	300	15.5	s. 64 w.	4,651	+ 6	0.499
Colorado Springs, Colo	n.	340	6,846	9.2	n.	281	11.3	n. 10 w.	3,106	−16	0.402
Davenport, Iowa	w.	207	8,399	11.3	s. 60 w.	353	13.7	s. 65 w.	4,850	+ 5	0.577
Denver, Colo	s.	192	6,456	8.7	s. 68 w.	213	11.1	s. 88 w.	2,370	+20	0.307
Des Moines, Iowa	nw.	198	6,198	8.3	n. 80 w.	242	10.2	n. 81 w.	2,475	− 1	0.399
Detroit, Mich	sw.	305	10,430	14.0	s. 73 w.	300	17.3	s. 72 w.	6,400	− 1	0.613
Dodge City, Kans	nw.	209	8,184	11.0	n. 58 w.	128	7.8	s. 71 w.	1,000	−48	0.122
Duluth, Minn	n.	180	5,073	6.8	n. 50 w.	275	7.3	n. 38 w.	2,000	+12	0.394
Eastport, Me	nw.	202	9,848	13.2	n. 58 w.	353	11.8	n. 39 w.	4,150	+19	0.421
El Paso, Tex	nw.	327	6,390	8.6	n. 32 w.	283	12.1	n. 30 w.	3,420	− 4	0.535
Galveston, Tex	se.	207	8,089	11.7	s. 40 e.	179	6.1	s. 53 e.	1,084	−13	0.124
Grand Haven, Mich	sw.	201	10,409	14.1	s. 75 w.	135	28.1	s. 68 w.	3,800	− 7	0.362
Havre, Mont	sw.	259	7,694	10.3	s. 81 w.	325	14.9	s. 70 w.	4,850	−11	0.631
Helena, Mont	sw.	416	6,320	8.5	s. 60 w.	500	10.1	s. 50 w.	5,650	− 4	0.893
Huron, S. Dak	nw.	223	9,489	12.8	n. 24 w.	88	15.8	n. 32 w.	1,392	− 8	0.147
Indianapolis, Ind	nw.	169	5,717	7.7	s. 50 w.	298	7.9	s. 54 w.	2,303	+ 4	0.413
Jacksonville, Fla	ne.	196	5,330	7.2	n. 7 w.	220	4.0	n. 10 w.	885	− 9	0.165
Kansas City, Mo	s.	182	8,162	19.7	s. 31 w.	168	14.3	s. 33 w.	2,408	+ 2	0.295
Keeler, Cal	se.	135	3,773	5.1	n. 66 e.	117	3.0	n. 19 e.	354	−47	0.094
Key West, Fla	ne.	410	9,332	12.5	n. 59 e.	510	13.4	n. 50 e.	6,817	− 9	0.731
Knoxville, Tenn	ne.	200	4,017	5.4	n. 38 w.	174	8.3	n. 80 w.	1,437	−42	0.350
Lynchburg, Va	sw.	223	3,319	4.5	s. 79 w.	228	6.5	n. 83 w.	1,487	+18	0.444
Marquette, Mich	w.	216	8,714	11.7	s. 85 w.	366	10.4	n. 85 w.	3,800	+10	0.436
Memphis, Tenn	nw.	147	6,057	8.1	s. 20 w.	98	6.8	s. 51 w.	665	+31	0.110
Milwaukee, Wis	nw.	244	8,671	12.1	.. .. w.	327	12.2	n. 89 w	3,980	+ 1	0.444
Moorhead, Minn	n.	224	8,294	11.1	n. 41 w.	167	8.1	n. 40 w.	1,350	+ 1	0.163
Nantucket, Mass	nw.	200	9,644	13.0	n. 28 w.	285	13.2	n. 13 w.	3,750	+15	0.389
Nashville, Tenn	nw.	160	5,000	6.7	s. 17 w.	75	14.5	s. 54 w.	1,087	+37	0.237
New Haven, Conn	sw.	187	6.725	9.0	n. 60 w.	282	9.6	n. 56 w.	2,700	+ 4	0.401
New Orleans, La	se.	141	6,870	9.2	.. .. e.	184	6.7	n. 51 e.	1,240	−37	0.181
New York, N. Y	sw.	215	8,598	11.6	s. 64 w.	301	13.1	s. 79 w.	3,940	+15	0.459
Norfolk, Va	sw.	190	7,037	9.5	n. 78 w.	190	13.3	s. 85 w.	2,531	−17	0.359
Olympia, Wash	s.	477	4,436	6.0	s. 6 w.	492	7.5	s. 7 w.	3,703	+ 1	0.834
Omaha, Nebr	nw.	201	5,945	8.0	s. 75 w.	127	8.4	s. 84 w.	1,054	+ 9	0.179
Philadelphia, Pa	sw.	223	8,168	10.9	n. 88 w.	288	12.6	n. 72 w.	3,625	+16	0.444
Pikes Peak, Colo	w.	222	24,216	32.5	n. 62 w.	315	41.3	n. 77 w.	13,000	−15	0.537
Pittsburg, Pa	w.	223	5,985	8.0	s. 62 w.	378	9.2	s. 69 w.	3,407	+ 7	0.580
Portland, Me	nw.	227	5,640	7.6	n. 69 w.	420	7.8	n. 66 w.	3,233	+ 3	0.572
Portland, Oregon	s. sw.	189 189	6,224	8.4	s. 23 w.	255	13.1	s. 28 w.	3,350	+ 5	0.539
Rochester, N. Y	sw.	361	7,192	9.7	s. 48 w.	390	11.6	s. 54 w.	4,525	+ 6	0.629
Roseburg, Oregon	e.	152	1,980	2.7	s. 38 e.	185	3.6	s. 23 e.	675	+15	0.341
Saint Louis, Mo	s.	167	10,450	14.0	s. 37 w.	191	21.8	s. 46 w.	4,167	+ 9	0.400
Saint Paul, Minn	se. nw.	164 162	5,759	7.7	s. 69 w.	133	12.6	n. 88 w.	1,677	+23	0.291
Salt Lake City, Utah	se.	205	3,256	4.4	s. 11 e.	145	4.1	s. 28 w.	593	+39	0.182
San Diego, Cal	ne.	171	3,327	4.5	n. 8 w.	233	3.8	n. 24 w.	884	−16	0.266
San Francisco, Cal	nw.	158	4,491	6.0	n. 63 w.	101	7.2	n. 72 w.	730	− 9	0.385
Santa Fe, N. Mex	ne.	202	5,112	6.9	n. 38 e.	155	9.2	n.	1,419	−38	0.278
Sault Ste. Marie, Mich	se.	214	6,535	8.8	.. .. e.	163	5.7	n. 83 e.	930	− 7	0.142
Savannah, Ga	nw.	157	6,091	8.2	n. 32 w.	139	8.8	n. 56 w.	1,230	−24	0.202
Spokane, Wash	sw.	186	3,988	5.4	s. 49 w.	120	15.9	s. 22 w.	1,908	−27	0.478
Toledo, Ohio	sw.	265	9,556	12.9	s. 62 w.	354	14.3	s. 59 w.	5,052	− 3	0.529
Vicksburg, Miss	se.	208	5,840	7.8	s. 64 e.	162	7.1	s. 36 e.	1,153	+28	0.197
Washington, D. C	s.	187	5,032	6.8	s. 83 w.	187	10.5	n. 77 w.	1,960	+20	0.390
Wilmington, N. C	sw.	191	6,409	8.6	n. 74 w.	223	9.3	n. 85 w.	2,072	−11	0.323
Yuma, Ariz	n.	273	4,929	6.6	n. 12 e.	390	7.6	n. 3 e.	2,994	− 9	0.607

and low centers; in December, 1893, positive differences are largely confined to the upper and lower Mississippi, the lower Missouri, and the Ohio valleys, the Middle States, and New England; another positive group extended from San Francisco, Cal., to Olympia, Wash., and these groups are connected by a belt of positives represented by Salt Lake City, Utah, Denver Col., and Omaha, Nebr.; the negative differences lie mostly north and south of these regions of positive differences. Column 12—if the wind movements were equal from each opposing pair of points of the compass the resultant movement in column 10 would be zero no matter how large the total movements in column 4 might be; therefore, the ratio of column 10 divided by column 4 gives an approximate idea of the extent to which the resultant movement or resultant direction has prevailed over the other winds of the month; this ratio would be unity in the ideal case of wind blowing from one single direction only, as is very nearly the case in the midst of the trade-wind region; the ratio would be zero in the ideal case of opposing day and night breezes of equal strength; during December, 1893, column 12 shows large ratios at Helena, Mont., Key West, Fla., and Olympia, Wash., and small ratios at Keeler, Cal., Memphis, Tenn., Dodge City, Kans., and Sault Ste. Marie, Mich.; on charting these ratios we perceive that in mountainous countries the topography has much to do with increasing the numbers, but that in a level country they depend upon what are called the "steady movements" of the atmosphere, viz., either a steady flow in one direction, as in the northeast trades, or a steady flow in re-entrant curves, as in the diurnal land and sea, mountain and plain breezes, or the monthly monsoon breezes.

Table B gives, for 140 stations, or all that make observations at 8 a. m. and 8 p. m., the four component directions and the resultant directions, based on these two observations only; the total movement for the whole month, as read from the dial of the Robinson anemometer, is given in the table of climatological data; any deductions that may be drawn from the study of the continuous registers at 67 stations can, therefore, be applied to the data from all other stations, as given in Table B. By adding the four components for the stations comprised in each geographical division we can obtain the average resultant direction for that region, and in the same way we may obtain the average for the whole United States.

TABLE B.—*Resultant winds from observations at 8 a. m. and 8 p. m. daily, or 62 hours, during December, 1893.*

Number.	Station.	Component direction from— N.	S.	E.	W.	Resultant direction. From.	Hours.
	New England.	*Hours.*	*Hours.*	*Hours.*	*Hours.*	°	
1	Eastport, Me	24	10	10	34	n. 60 w.	28
2	Portland, Me	22	14	2	39	n. 78 w.	38
3	Northfield, Vt	23	22	2	11	n. 84 w.	9
4	Boston, Mass	18	12	4	41	n. 80 w.	37
5	Nantucket, Mass	33	13	10	21	n. 29 w.	23
6	Woods Holl, Mass	10	5	2	19	n. 74 w.	18
7	Block Island, R. I	27	12	9	33	n. 58 w.	28
8	New Haven, Conn	26	12	7	31	n. 60 w.	28
9	New London, Conn	25	13	4	35	n. 68 w.	33
	Middle Atlantic states.						
10	Albany, N. Y	20	24	6	19	s. 73 w.	14
11	New York, N. Y	16	28	6	28	s. 70 w.	23
12	Harrisburg, Pa	15	15	19	25	... .. w.	6
13	Philadelphia, Pa	20	18	8	29	n. 85 w.	21
14	Atlantic City, N. J	20	17	6	32	n. 83 w.	26
15	Baltimore, Md	19	19	10	29	... .. w.	19
16	Washington, D. C	23	23	6	17	... .. w.	11
17	Lynchburg, Va	16	16	14	30	... .. w.	16
18	Norfolk, Va	21	21	10	25	... .. w.	15
	Atlantic states.						
19	Charlotte, Va	14	27	19	22	s. 12 w.	13
20	Hatteras, N. C	23	15	10	30	n. 68 w.	22
21	Kittyhawk, N. C	20	16	11	30	n. 78 w.	20
22	Raleigh, N. C	22	23	5	29	s. 88 w.	24
23	Southport, N. C	27	6	9	31	n. 46 w.	30
24	Wilmington, N. C	22	20	10	27	n. 83 w.	17
25	Charleston, S. C	26	17	14	19	n. 29 w.	10
26	Augusta, Ga	24	13	15	21	n. 29 w.	13
27	Savannah, Ga	24	16	14	23	n. 48 w.	12
28	Jacksonville, Fla	33	12	13	17	n. 11 w.	21
	Florida peninsula.						
29	Jupiter, Fla	24	12	26	16	n. 40 e.	16
30	Key West, Fla	33	6	37	4	n. 50 e.	43
31	Tampa, Fla	35	10	23	10	n. 28 e.	28
32	Titusville, Fla	29	13	14	26	n. 37 w.	20
	Eastern Gulf states.						
33	Atlanta, Ga	17	19	15	27	s. 81 w.	12
34	Pensacola, Fla	27	18	21	11	n. 48 e.	14
35	Mobile, Ala	30	14	10	16	n. 21 w.	17
36	Montgomery, Ala	24	16	17	19	n. 14 w.	8
37	Meridian, Miss	28	16	18	12	n. 27 e.	13
38	Vicksburg, Miss	20	19	29	12	n. 87 e.	17
39	New Orleans, La	20	20	26	8	... .. e.	18
	Western Gulf states.						
40	Shreveport, La	14	27	21	14	s. 28 e.	15
41	Fort Smith, Ark	14	11	34	13	n. 82 e.	21
42	Little Rock, Ark	19	22	15	22	s. 67 w.	8
43	Corpus Christi, Tex	21	25	28	9	s. 77 e.	20
44	Galveston, Tex	13	30	25	16	s. 28 e.	19
45	Palestine, Tex	22	19	17	19	n. 34 w.	4
46	San Antonio, Tex	22	20	21	14	n. 74 e.	7
	Ohio Valley and Tennessee.						
47	Chattanooga, Tenn	21	24	14	18	s. 53 w.	5
48	Knoxville, Tenn	24	13	17	22	n. 24 w.	12
49	Memphis, Tenn	19	24	16	18	s. 22 w.	5
50	Nashville, Tenn	19	25	19	16	s. 27 e.	7
51	Lexington, Ky	18	26	10	32	s. 70 w.	24

TABLE B.—*Resultant winds from observations, etc.*—Continued.

Number.	Station.	Component direction from— N.	S.	E.	W.	Resultant direction. From.	Hours.
	Ohio Valley and Tennessee—Cont'd.	*Hours.*	*Hours.*	*Hours.*	*Hours.*	°	
52	Louisville, Ky	15	29	11	21	s. 36 w.	17
53	Indianapolis, Ind	12	28	10	25	s. 43 w.	22
54	Cincinnati, Ohio	14	23	14	24	s. 48 w.	13
55	Columbus, Ohio	15	24	8	26	s. 63 w.	20
56	Pittsburg, Pa	10	25	9	33	s. 58 w.	28
57	Parkersburg, W. Va	7	30	11	25	s. 32 w.	27
	Lower Lake region.						
58	Buffalo, N. Y	20	16	7	35	n. 82 w.	28
59	Oswego, N. Y	12	29	13	22	s. 28 w.	19
60	Rochester, N. Y	8	31	8	33	s. 47 w.	34
61	Erie, Pa	12	31	3	31	s. 56 w.	34
62	Cleveland, Ohio	10	35	14	18	s. 9 w.	25
63	Sandusky, Ohio	10	24	5	37	s. 66 w.	35
64	Toledo, Ohio	11	29	7	33	s. 55 w.	32
65	Detroit, Mich	13	23	10	35	s. 68 w.	27
	Upper Lake region.						
66	Alpena, Mich	18	20	9	30	s. 85 w.	21
67	Grand Haven, Mich	17	20	15	28	s. 77 w.	13
68	Marquette, Mich	13	17	4	36	s. 83 w.	32
69	Port Huron, Mich	15	24	6	33	s. 72 w.	29
70	Sault Ste. Marie, Mich	18	17	30	14	n. 87 e.	16
71	Chicago, Ill	13	23	3	36	s. 73 w.	34
72	Milwaukee, Wis	21	20	7	30	n. 88 w.	23
73	Green Bay, Wis	21	24	7	22	s. 79 w.	15
74	Duluth, Minn	25	13	10	28	n. 56 w.	22
	Extreme Northwest.						
75	Moorhead, Minn	28	20	8	15	n. 41 w.	11
76	Saint Vincent, Minn	32	16	10	7	n. 11 e.	16
77	Bismarck, N. Dak	26	11	18	19	n. 4 w.	15
78	Williston, N. Dak	16	19	16	20	s. 53 w.	5
	Upper Mississippi Valley.						
79	Saint Paul, Minn	19	17	14	27	n. 81 w.	13
80	La Crosse, Wis	19	20	14	19	s. 79 w.	5
81	Davenport, Iowa	8	21	8	34	s. 64 w.	29
82	Des Moines, Iowa	17	12	12	31	n. 75 w.	20
83	Dubuque, Iowa	15	22	10	27	s. 68 w.	18
84	Keokuk, Iowa	15	26	8	27	s. 60 w.	22
85	Cairo, Iowa	19	30	10	15	s. 25 w.	12
86	Springfield, Ill	16	27	6	24	s. 58 w.	21
87	Hannibal, Mo	16	25	8	26	s. 63 w.	20
88	Saint Louis, Mo	14	27	15	20	s. 21 w.	14
	Missouri Valley.						
89	Columbia, Mo	10	12	5	13	s. 76 w.	8
90	Kansas City, Mo	17	28	13	17	s. 20 w.	12
91	Springfield, Mo	18	30	15	16	s. 5 w.	12
92	Omaha, Nebr	17	22	13	21	s. 58 w.	10
93	Valentine, Nebr	20	10	6	38	s. 72 w.	34
94	Sioux City Iowa	23	18	20	16	n. 39 e.	7
95	Pierre, S. Dak	22	17	24	18	n. 50 e.	8
96	Huron, S. Dak	25	18	18	19	n. 8 w.	7
97	Yankton, S. Dak	23	15	16	26	n. 52 w.	13
	Northern slope.						
98	Havre, Mont	17	17	12	36	... .. w.	24
99	Miles City, Mont	11	21	17	21	s. 22 w.	11
100	Helena, Mont	3	27	1	44	s. 61 w.	48
101	Rapid City, S. Dak	15	10	12	36	n. 78 w.	25
102	Cheyenne, Wyo	24	9	4	36	n. 65 w.	35
103	Lander, Wyo	9	27	9	30	s. 50 w.	28
104	Kearney, Nebr	20	14	8	33	n. 76 w.	26
105	North Platte, Nebr	12	19	8	40	s. 78 w.	33
	Middle slope.						
106	Colorado Springs, Colo	37	10	12	13	n. 2 w.	27
107	Denver, Colo	21	21	8	27	... .. w.	19
108	Pikes Peak, Colo	26	11	4	30	n. 60 w.	30
109	Pueblo, Colo	14	10	13	32	n. 78 w.	20
110	Concordia, Kans	14	24	9	28	s. 63 w.	22
111	Dodge City, Kans	23	21	11	24	n. 81 w.	13
112	Wichita, Kans	19	32	8	15	s. 28 w.	15
113	Oklahoma, Okla	18	30	12	16	n. 18 w.	13
	Southern slope.						
114	Abilene, Tex	20	30	10	17	s. 35 w.	12
115	Amarillo, Tex	19	28	6	18	s. 53 w.	15
	Southern plateau.						
116	El Paso, Tex	28	8	17	24	n. 19 w.	21
117	Santa Fe, N. Mex	23	19	26	8	n. 77 e.	18
118	Tucson, Ariz	16	23	22	16	s. 41 e.	9
119	Yuma, Ariz	39	8	15	10	n. 9 e.	31
120	Keeler, Cal	19	17	20	17	n. 56 e.	4
	Middle plateau.						
121	Winnemucca, Nev	12	22	21	18	s. 17 e.	10
122	Salt Lake City, Utah	18	18	22	20	.. ... e.	2
	Northern plateau.						
123	Baker City, Oreg	7	35	25	12	s. 26 e.	30
124	Idaho Falls, Idaho	13	35	6	20	s. 33 w.	26
125	Spokane, Wash	15	27	12	17	s. 23 w.	13
126	Walla Walla, Wash	6	36	13	12	s. 2 e.	30
	North Pacific coast region.						
127	Fort Canby, Wash	7	23	22	20	s. 7 e.	16
128	Olympia, Wash	6	48	5	8	s. 4 w.	42
129	Port Angeles, Wash	2	46	7	14	n. 9 w.	45
130	Seattle, Wash	5	39	19	5	s. 22 e.	37
131	Tatoosh, Island, Wash	3	31	22	20	s. 4 e.	28
132	Portland, Oreg	14	31	11	20	s. 28 w.	19
133	Roseburg, Oreg	9	23	26	15	s. 38 e.	18
	Middle Pacific coast region.						
134	Eureka, Cal	20	25	14	12	s. 22 e.	5
135	Red Bluff, Cal	26	16	12	27	n. 56 w.	18
136	Sacramento, Cal	17	29	19	13	s. 26 e.	13
137	San Francisco, Cal	20	16	13	23	n. 68 w.	11
	South Pacific coast region.						
138	Fresno, Cal	20	15	19	21	n. 22 w.	5
139	Los Angeles, Cal	31	4	21	24	n. 7 w.	27
140	San Diego, Cal	27	10	14	24	n. 30 w.	20